Epidemiology and Control of Alternaria Leaf Spot

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Interpretive Summary:

The development of additional classes of fungicides that are highly effective for managing Alternaria leaf spot on almond is essential because the most effective fungicides that are currently registered with an appropriate use pattern all belong to the strobilurin class of fungicides with a similar single-site mode of action. Strobilurin-resistant isolates of *Alternaria* spp. were commonly found in 2006 and in 2007 in locations in Kern Co. where the disease was not controlled to satisfactory levels after applications with strobilurin fungicides. Thus, in order to maintain the strobilurins as highly effective fungicides for managing foliar diseases of almond, our studies focused on generating efficacy data to identify new effective fungicides of different chemical classes for potential registration and use in rotation with the strobilurins. Avoidance of the occurrence of field resistance, however, may be too late in many orchards. Still, rotational programs of different classes and mode of action of effective fungicides are our best strategy to prevent widespread regional or statewide loss of the strobilurin fungicides to control Alternaria and other foliar diseases of almond. Pristine was re-labeled for late-spring to early-summer use patterns with a 25-day preharvest interval (PHI). Efforts are also underway to re-label Rovral through the IR-4 program but regulatory concerns have developed that will likely cause extended delays in obtaining the requested label changes. At best, these products are suppressive as currently registered. In our 2006 trials in Kern Co., three calendar-based applications of the antibiotic polyoxin-D, an experimental SBI material (CGA-169374 or Inspire - difenconazole), or a SBI-strobilurin pre-mixture (USF2010 or Adamant) were highly effective in reducing the incidence of disease from the control and they performed similar to or significantly better than multiple applications of Abound, Pristine, Vangard, or Scala. With support from the Almond Board of California, IR-4 residue studies have been conducted in 2006 to accelerate registration of the new SBI material Inspire for late spring and early summer usage. Additionally, an emergency registration is being developed for Inspire in 2007 for the 2008 season. The identification of other products

must be continued to provide an effective rotation program of products with different modes of action. In 2007 label modifications were made to Scala and Captan labels to include suppression of Alternaria leaf spot with late spring (up to 30-day PHI intervals). In our field trials in 2006 we also compared the efficacy of five-week-after-petal-fall applications with either Bravo-Rovral, Captan-Rovral, or Ziram-Rovral. Only the Captan-Rovral application significantly reduced the incidence and severity of disease, but additional late-spring fungicide applications were required to obtain a high level of disease control. These studies are being repeated in 2007. Growth chamber experiments under controlled temperature-wetness conditions demonstrated that mite and insect control is an important component of an integrated management strategy for Alternaria leaf spot. Only plants with mite injuries developed disease symptoms in these studies, but not the healthy plants without injuries.

Objectives:

I. Etiology
   - A. Identify pathogenic species of *Alternaria* using molecular methods.
   - B. Determine the pathogen species composition within and between selected orchards at the beginning and at the end of the log phase of the epidemic. This objective is contingent on the development of molecular methods for identification of the pathogens.

II. Epidemiology
   - A. Growth chamber studies to evaluate disease development under defined environmental conditions (wetness, relative humidity, temperature).
   - B. Develop disease progress curves in relation to microclimates in commercial orchards.
     - i. Continue to compare environmental parameters (wetness, relative humidity, temperature) occurring at the edges and within an orchard and relate these to disease development.
     - ii. Continue to compare environmental parameters between different orchards and relate to disease development. Dataloggers will be placed in these different locations.
   - C. Continue to evaluate the DSV model as a method of forecasting the disease with the goal of improved timing of fungicide treatments.
     - i. Evaluate the minimum temperature modified-DSV model, as well as 10- and 20-point thresholds of the 7-day index of the DSV model for predicting disease and timing of fungicides.
     - ii. Determine optimal fungicide application timings based on different methods for calculating thresholds of the DSV model.

III. Management
   - A. Evaluate new fungicides for their efficacy in managing Alternaria leaf spot. Fungicides to be evaluated include Pristine (pyraclostrobin + boscalid) and non-strobilurin fungicides (e.g., Elite, difenconazole – Inspire, polyoxin, and kasugamycin, as well as other experimentals) and compare efficacy to strobilurin fungicides (Abound, Flint, Pristine).
   - B. Evaluate rotation programs that use calendar-based fungicide applications in comparison with applications based on the modified DSV model.

C. Monitor for strobilurin field-resistance and shifts in sensitivity in populations of *Alternaria* spp.

Introduction. Alternaria leaf spot of almond is a disease that is caused by three species in the *Alternaria alternata* complex, *A. arborescens*, *A. alternata*, and *A. tenuissima*. Under favorable conditions for disease development, trees can be completely defoliated by early to mid-summer. The disease occurs throughout the almond production areas in the central valleys of California. It is most serious in the lower San Joaquin valley where dew forms, the air is stagnant, and temperatures are high. In other areas including the northern Sacramento valley, almonds sometimes have been planted in poorer soils and irrigation practices have changed and include more frequent and extended watering into the summer. This situation has increased the occurrence of the disease and in 2006 and 2007, there were several reports on serious disease outbreaks in the Northern growing areas.

Because the occurrence of Alternaria leaf spot of almond is greatly influenced by microclimatic conditions such as temperature and wetness within orchards, the Disease Severity Value (DSV) model that is used for forecasting of Alternaria diseases on other crops was evaluated on almond in our previous years' studies. We demonstrated a close correlation between the increase in actual disease increase and increases in DSV that are determined by the number of hours of wetness within defined temperature ranges. In subsequent studies, we adjusted threshold temperatures to greater than or equal to 62 F to refine the accuracy of the model for almond in California. In addition, we demonstrated that the development of the actual disease incidence correlated to environmental conditions that occurred 25 days (± 3 days) before the onset of disease symptoms (the disease progress curve latency period). Thus, temperature-leaf wetness conditions used for calculation of the DSVs reflect the actual disease development. The DSV model is a tool for predicting infection periods for the Alternaria pathogen on almond and for timing of fungicide applications.

Materials and Methods:

Progress on new and amended fungicide registrations. For management of Alternaria spot, currently the strobilurin fungicides (e.g., azoxystrobin - Abound, trifloxystrobin - Flint, pyraclostrobin/boscalid - Pristine) and Rovral are registered. There are limitations with the use of these fungicides, however, that emphasize the need for identification and development of new materials. With the strobilurins, a major concern is resistance in pathogen populations that we documented three years ago on almond, although no crop losses had occurred at that time. Strobilurin resistance together with crop losses, however, has been reported on pistachio. A limitation with Pristine and Rovral was that these two fungicides were registered only up to 5 weeks after petal fall and thus, were not available when the disease occurs in late spring and early summer. Following our request, the PHI interval for Pristine was changed for a shorter interval that now allows usage up to 24 days before harvest. The label for Rovral, however, still only includes applications up to 5 weeks after petal fall (immediate changes to the label for extended usage in the spring are unlikely due to regulatory concerns). Follow-ups on the registration of progress of difenoconazole and polyoxin-D were also made a prioirity.

Growth chamber studies to evaluate disease development under defined environmental conditions. Inoculations of potted cv. Carmel and Sonora almond plants were conducted in growth chamber experiments under defined temperature-humidity conditions. Two kinds of plants were used: healthy plants and plants that were previously infested with mites and that were treated with a miticide before the experiment. After inoculation with conidia of representatives of the three *Alternaria* species affecting almonds (*A. alternata, A. tenuissima, A. arborescens*) plants were incubated at >95% relative humidity and at day/night temperatures of 30 C/25 C.

Fungicide evaluations for management of Alternaria leaf spot of almond in 2006 and 2007. In 2006, two split-plot field trials were established in Kern Co. The first trial was on cvs. Carmel, Fritz, and Monterey; whereas, the second trial was only on cv. Carmel. In 2007, two split-plot field trials on cvs. Carmel and Monterey in Kern, a trial in Colusa Co., and a third late spring season trial on cv. Monterey were also established in Kern Co. In the split plots of both years, the main plots received five-week-after petal-fall applications with mixtures of Bravo and Rovral, Captan and Rovral, or Ziram and Rovral or only Captan, or they received no application (control treatment). In the second trial on cv. Carmel, trees were also treated with a subsequent calendar-based, three-spray program (In 2006, mid-May, early June, and mid-June; whereas in 2007, in mid- and late June); whereas in the late season trial on Carmel in Kern Co were done in Mid- and late June. Treatments in al trials included a strobilurin fungicide (i.e., Abound), a strobilurin in pre-mixtures with a carboxyanilide (i.e., Pristine) or a SBI fungicide (i.e., USF2010), a SBI fungicide (i.e., Inspire), two hydroxyanilides (i.e., Vangard, Scala), the antibiotic polyoxin (i.e., Endorse), or a rotation of selected fungicides. For disease evaluation in the field, trees were rated for defoliation based on a scale from 0 (= no defoliation) to 4 (= more than 75% of the leaves had fallen). For the laboratory evaluation ca. 100 leaves from each of six single-tree replications were collected and evaluated for the incidence (% leaves infected of the total number of leaves) and severity (number of lesions/leaf) of Alternaria spot.

<u>Results and Discussion:</u>

Progress on new and amended fungicide registrations. Based on discussions with Bayer Crop Science representatives that indicated that the toxicity of Rovral was recently downgraded, a proposal to change the label of the fungicide on almond was made at the 2006 IR-4 Food Use Workshop. Thus, an A priority upgrade was obtained to initiate studies in 2007 to change the preharvest interval for Rovral to 60 days. This label change was pursued but in 2007 the EPA announced additional concerns about the environmental fate of this chemistry and is currently requesting that Bayer re-evaluate the chemistry in a series of additional studies.

In our field trials in 2005 the two new fungicides Inspire (difenconazole) and Endorse (polyoxin-D) were among the most effective treatments evaluated. Difenconazole is a sterol biosynthesis inhibiting (SBI) fungicide that is registered in other countries for the control of several diseases including those caused by *Alternaria* spp., whereas polyoxin is an antibiotic that registered in the US on turf for the control of *Rhizoctonia* spp. and in other countries also for the control Alternaria diseases. With financial support from the Almond Board of California, IR-4 residue studies were recommended and the field portion of the registration process for difenconazole was completed in 2006. Submission to EPA is planned in 2007/08, and a registration on almond is expected in 2009/10. Registration of difenoconazole (Inspire) is being pursued through the IR-4 program and a Section 18 emergency registration is being developed for the 2008 season in cooperation with Syngenta Crop Protection and the California Almond Board. Arysta Life Science has also requested an all-crop registration of polyoxin-D at 20 g/A. This registration request is pending EPA review.

Growth chamber studies to evaluate disease development under defined environmental conditions. After 10-14 days of incubation, Alternaria symptoms and sporulation of the fungus on the leaves only developed on the mite-injured plants, but not on the healthy plants, and all three species of the pathogen caused disease. Thus, we demonstrated that mite-injured almond leaves are much more susceptible to Alternaria leaf spot indicating that a complex of factors is involved in Alternaria leaf spot outbreaks on almond. Therefore, mite and insect control is important in the management of this fungal disease.

Fungicide evaluations for management of Alternaria leaf spot of almond in 2006 and 2007. In the first trial conducted in 2006, five-week-after-petal-fall applications (Bravo-Rovral, Captan-Rovral, Ziram-Rovral) were evaluated on cvs. Carmel, Monterey, and Fritz. Based on our tree defoliation rating, the variable cultivar and the interaction of cultivar and 5-wk-after-petal fall treatments were not significant. The 5-wk-after petal fall treatment, however, was significant. This means that the five-week-after-petal-fall treatments performed similar on the three cultivars. In Table 1, the efficacy of these treatments across all cultivars is shown. There was no significant difference between the Bravo-Rovral and Ziram-Rovral treatments as compared to the non-treated control (Table 1). A single Captan-Rovral treatment at five weeks after petal fall, however, significantly reduced the rating from 1.7 in the control to 1.05. Still, this treatment is not self-standing and additional fungicide treatments in late spring are required. The Bravo-Rovral treatments were apparently phytotoxic and increased disease (Table 1).

Table 1. Evaluation of five-week-after-petal-fall treatments for management of Alternaria leaf spot on almond cvs. Carmel, Monterey, and Fritz - Kern Co. 2006

		Product	Application	Tree defoliation rating	
No.	Treatment*	Rate	26-Apr	Rating**	LSD***
1	Control	---	@	1.7	a
2	Bravo 720-Rovral 4F	6 qt-1 pt	@	1.86	a
3	Captan 80WP-Rovral 4F	6.25 lb-1 pt	@	1.05	b
4	Ziram 75WP-Rovral 4F	8 lb-1 pt	@	1.53	ab

* - Treatments were applied using an air-blast sprayer at a rate of 100 gal/A.

** - Evaluations were done on 8-11-06. Rating for tree defoliation: 0 (= no defoliation) to 4 (>75% of the leaves fallen).

***- In the statistical analysis data for the cultivars were combined because there was no significant differences in defoliation between the three almond cultivars. Values followed by the same letter are not significantly different based on an analysis of variance and LSD mean separation ($P > 0.05$).

In the laboratory evaluations on the incidence and severity of disease from collected leaves, there was no difference between any of these treatments and the control, but differences among cultivars were observed. Thus, in the cultivar comparison in Table 2, cv. Carmel was the most susceptible to Alternaria leaf spot, whereas cv. Fritz was the least susceptible.

Table 2. Evaluation of five-week-after-petal-fall treatments for management of Alternaria leaf spot on almond cvs. Carmel, Monterey, and Fritz - Kern Co. 2006

		Laboratory evaluation***			
No.	Almond cultivar	Inc. (%)	LSD	Severity	LSD
1	Carmel	50.0	a	1.38	a
2	Monterey	40.2	a	1.09	a
3	Fritz	15.3	b	0.32	b

* - Treatments as in Table 1A were applied using an air-blast sprayer at a rate of 100 gal/A.

** - Evaluations were done on 8-11-06. For the laboratory evaluation ca. 100 leaves from each of the three or six single-tree replications were collected and evaluated for the incidence (% leaves infected of the total number of leaves) and severity (number of lesions/leaf) of Alternaria spot.

***- In the statistical analysis there was no significant differences between the control and the three five-week after petal fall treatments. Thus, data for the control and the treatments were combined and analyzed for differences among cultivars. Values followed by the same letter are not significantly different based on an analysis of variance and LSD mean separation ($P > 0.05$).

In the second trial in 2006, on cv. Carmel (a highly susceptible cultivar), there was no interaction between five-week-after-petal-fall treatments and the subsequent three-spray fungicide program for tree defoliation as well as disease incidence and severity. This means that the subsequent three-spray fungicide programs performed similarly after each of the five-week-after-petal-fall treatments. Thus, in Table 3 data for the sub-plots within the main plots were combined. Similar to the first trial described above, the five-week-after-petal-fall applications had a significant effect on disease incidence and severity but not on tree defoliation. Thus, a single Captan-Rovral treatment at five weeks after petal fall significantly decreased the incidence of Alternaria leaf spot as compared to the control (Table 3). In the non-treated control 24% of the leaves had symptoms of Alternaria spot and 0.6 lesions were found on average on each leaf. For the five-week-after-petal-fall applications with Captan-Rovral, these values were 18% for disease incidence and 0.44 lesions/leaf. Similar to the first trial, the Bravo-Rovral treatment was apparently phytotoxic and increased disease (Table 3). Thus, only the five-weeks-after-petal-fall application with Captan-Rovral was an effective treatment for Alternaria leaf spot control, but additional late-spring fungicide applications were required to obtain a high level of disease control.

Table 3. Evaluation of five-week-after petal-fall treatments for management of Alternaria leaf spot on cv. Carmel - Kern Co. 2006

No.	Treatment*	Rate	Application Dates				Tree defoliation		Laboratory evaluation***			
			4-26	5-19	6-1	6-13	Rating**	LSD	Inc. (%)	LSD	Severity	LSD
1	Control	---	@	---	---	---	1.3	a	24.0	B	0.60	b
2	Bravo 720-Rovral 4F	6 qt-1 pt	@	---	---	---	1.6	a	38.6	A	1.00	a
3	Captan 80WP-Rovral 4F	6.25 lb-1 pt	@	---	---	---	1.1	a	18.0	C	0.44	c

* - Treatments were applied using an air-blast sprayer at a rate of 100 gal/A.

** - Evaluations were done on 8-11-06. Rating for tree defoliation was based on a scale from 0 (= no defoliation) to 4 (>75% of the leaves fallen).

*** - For the laboratory evaluation ca. 100 leaves from each of the six single-tree replications were collected and evaluated for the incidence (% leaves infected of the total number of leaves) and severity (number of lesions/leaf) of Alternaria spot. Values followed by the same letter are not significantly different based on an analysis of variance and LSD mean separation (P > 0.05).

Comparisons of fungicides in calendar-based, three-spray programs were made across all five-week-after-petal-fall treatments because these latter treatments did not affect their performance. Fungicides in the three-spray program significantly affected tree defoliation, disease incidence, and disease severity (Table 4). Tree defoliation was the lowest after applications with Inspire, followed by USF2010 and Pristine (Table 4). Defoliation after three Abound treatments was statistically similar to the control and the remaining treatments had an intermediate efficacy. In the laboratory evaluations of the field samples, Inspire (a SBI fungicide) was the most effective treatment and significantly reduced disease incidence and severity from that of the control. Disease incidence was 50% for the control and 6.3% for Inspire, and there were 1.37 lesions per leaf in the control and 0.13 lesions in the Inspire treatment (Table 4). In the SBI-strobilurin mixture USF2010, 15.6% of the leaves were diseased with an average of 0.36 lesions per leaf.

The two rates of Endorse reduced disease incidence and severity by ca. 50%, similar to Pristine, Scala, and the rotation program. Numerically, Abound and Vangard were the least effective treatments, but disease was still significantly lower than in the control (Table 4). In our previous years' trials, efficacy of Abound and also Pristine had been much higher. The reduced efficacy of these strobilurins indicates that field resistance in *Alternaria* spp. populations is now developing. This correlated with in vitro sensitivity studies where most isolates of *Alternaria* spp. collected from our field plot in 2006 were resistant to strobilurins. There was no multiple resistance of the strobilurin-resistant isolates to difenconazole. Field and lab studies are being repeated in 2007 and data are pending.

These data indicate that, similar to 2005, the new SBI fungicide Inspire is a highly effective treatment for the control of Alternaria leaf spot of almond. The SBI-strobilurin pre-mixture USF2010 was also very effective, but not as effective as Inspire, possibly because of the reduced rate of the SBI in this mixture. Thus, with IR-4 residue studies completed and registration on almond being supported by the registrant of Inspire, this fungicide will be instrumental in the management of Alternaria leaf spot of almond. Additionally, the USF2010 pre-mixture product should be pursued for registration but concerns exist because one of the components of this product is a strobilurin fungicide.

Table 4. Evaluation of fungicides for management of Alternaria leaf spot on cv. Carmel - Kern Co. 2006

No.	Treatment*	Rate	Application Dates				Tree defoliation		Laboratory evaluation***			
			4-26	5-19	6-1	6-13	Rating**	LSD	Inc. (%)	LSD	Severity	LSD
1	Control		---	---	---	---	2.21	a	50.0	a	1.37	a
2	Inspire 250EC	7 fl oz	---	@	@	@	0.42	d	6.3	e	0.13	e
3	USF2010 50WG	6 oz	---	@	@	@	0.88	cd	15.6	d	0.36	d
4	Endorse 11.2WG	25 g ai	---	@	@	@	1.08	c	26.2	bc	0.58	bc
5	Endorse 11.2WG	20 g ai	---	@	@	@	1.17	c	23.5	cd	0.52	cd
6	Pristine 38WG	0.92 lb	---	@	@	@	0.89	cd	24.3	c	0.56	cd
7	Scala 600SC	18 fl oz	---	@	@	@	1.44	bc	22.7	cd	0.57	bc
8	Abound 2F	12.8 fl oz	---	@	@	@	1.81	ab	34.7	b	0.87	b
9	Vangard 75WG	10 oz	---	@	@	@	2.08	a	31.9	bc	0.91	b
10	Abound 2F	12.8 fl oz	---	@	---	---	1.08	c	26.7	bc	0.77	bc
	Inspire 250EC	7 fl oz	---	---	@	---						
	Pristine 38WG	0.92 lb	---	---	---	@						

* - Treatments were applied using an air-blast sprayer at a rate of 100 gal/A. Treatment 10 was a rotational program.

** - Evaluations were done on 8-11-06. Rating for tree defoliation was based on a scale from 0 (= no defoliation) to 4 (>75% of the leaves fallen).

*** - For the laboratory evaluation ca. 100 leaves from each of the three or six single-tree replications were collected and evaluated for the incidence (% leaves infected of the total number of leaves) and severity (number of lesions/leaf) of Alternaria spot. Values followed by the same letter are not significantly different based on an analysis of variance and LSD mean separation ($P > 0.05$).

The antibiotic Endorse was more effective in our previous trials in 2004 and 2005. Still, in 2006, Alternaria leaf spot incidence and severity were significantly reduced as compared to the control. Additional research is needed on the rates, timing of application, and persistence of polyoxin-D to optimize its performance. Because polyoxin-D belongs to a different class than the SBI fungicides and thus, has a different mode of action, registration should be pursued to be able to design resistance management strategies that include fungicide rotations between different classes of fungicides and mixtures. Because field resistance is developing against the strobilurin fungicides, additional alternative materials with activity against *Alternaria* spp. have to be identified. Because of the current limited arsenal of chemical treatments available, other components of an integrated approach in disease management are even more critical. These include insect and mite control as well as cultural practices that lead to a decreased humidity in the micro-environment in the orchard including hedging, improvement of water penetration into the soil by adding gypsum, and changing the watering or irrigation schedule to less frequent irrigation using soil moisture probes. If all components of the disease triangle are considered, fungicide treatments will be the most beneficial. Additional trials with Endorse and DMI fungicides will be summarized later in 2007.

Guidelines for Alternaria Leaf Spot Management

By Mario Viveros and J. E. Adaskaveg

Alternaria Leaf Spot

Alternaria leaf spot is a fungal disease of almond leaves. The disease develops in late spring and early summer and may cause pre-mature defoliation of trees. The disease is caused by species of *Alternaria* in the *Alternaria alternata* complex – *A. alternata, A. tenuissima,* and *A. arborescens.*

Location

Alternaria leaf spot is most common in the low areas of the San Joaquin Valley (Rosedale, Shafter, Wasco, McFarland, Pond and Delano) but is found throughout almond growing regions of the state, especially in locations with high humidity (e.g., along rivers, low spots where dew accumulates, and in orchards where soils require frequent irrigation schedules).

Variety Selection

Most Susceptible Varieties: Carmel, Mission, Sonora, Price, Yokut, Kahl, Johlyn, Winters, W.Colony, Chips and Morley.

Less Susceptible Varieties: Fritz, Savana, Plateau, Sano, Jenette, Butte, Ruby, 2-19E, Livingston, Monterey and Savana.

Most Tolerant: Padre, Aldrich, Rosetta, Nonpareil and Kapareil.

Planting Arrangements – to allow air circulation

Good-Deep Soils: On the square (22 x 22 ft) and on the rectangle (24 x 22 ft).

Good-Shallow Soils: On the rectangle (24 x 18 ft or 22 x 18 ft).

Row Direction: It should be North-South.

Tree Training – to reduce dew formation

Tree Shape: Trees should be trained to an upright position. This can be accomplished by cutting a topping 6 to 12 inches from the treetops. To maintain the tree limbs upright, the topping should be done after the first growing season, then, repeated for the next three growing seasons. In addition to the topping, the trees should be tied each year. Depending on the crop load, trees may need double or triple ties. In general, pruning will allow more light penetration and reduce shading out (forced senescence from lack of pruning) of the inside canopy.

Foliar Disease Control – to decrease the amount of diseased (stressed) leaf tissue

Shot Hole: Effective fungicides are Pristine®, Rovral®, Captan®, and Ziram®.

Scab: Effective fungicides are Pristine®, Abound®, Flint®, Topsin-M®, and Ziram®.

Rust: Effective fungicides are Pristine®, Abound®, Flint®, Maneb®, and wettable sulfur.

Mite Control – to decrease the amount of injured leaf tissue

Water Stress: Mite Control depends on tree water stress management. The "pressure bomb" allows us to monitor the tree's water status.

Dust Control: Dust prevention will reduce mites in soil and spores of *Alternaria* species on decaying organic materials to be transported in dust to leaves in the tree canopy.

Chemical Control: Agri-Mek® has been effective in most orchards. New miticides are being registered at this time.

Irrigation Management – to reduce relative humidity in the orchard

Water Penetration: This may be overcome by the use of gypsum and cover crops (barley).

Prolong Wet Soil Surface: Adjust irrigation frequencies to allow the surface soil to dry between irrigations.

Chemical Control

Fungicides: Strobilurins (e.g., Abound-28 day PHI, Flint-60 day PHI, Pristine-25 day PHI) are most effective when applied in late April to late June. Pathogen populations have a high potential to develop resistance to fungicides in this chemical class (i.e., strobilurins) when the fungicides are over used. Resistance has been documented in a number of orchards throughout California. New chemistries such as Pristine (pre-mix of two active ingredients –pyraclostrobin and boscalid) and difenconazole that can be used in rotation programs will be available in the future for this spring period. Other fungicides such as Rovral, Bravo, or Rovral-Captan used in the petal fall period and Scala and Captan used up to 30 days PHI have only suppressive activity and need to be used in conjunction with other fungicides in the late April to late June period.

Timing: Two to three applications between mid-April and late-June depending on favorable environmental conditions (early treatments are most important). A model is being developed that will predict infection periods of the pathogen and thus, optimum spray application dates for managing the disease. Research done to date indicates that infection periods predicted by the model coincide with the effectiveness of early treatments starting in late April and early May.

Orchard Floor Management

Clean Cultivation: Clean cultivation reduces the moisture content in the air or relative humidity in the orchard that is generated from transpiring plants (cover crops, weeds, etc.) and thus, reduces the amount of dew in fluctuating day/night temperatures. Reduced vegetation also reduces the amount of senescing plant tissue being colonized by *Alternaria* species and, in turn, reduces the amount of spores of *Alternaria* sp. in the air that may function as inoculum for stressed almond leaves.

Chemical Mowing: A method of clean cultivation that reduces the potential for dust from cultivation and mowing equipment.